ARGENTINA

ABSTRACT

The co-control benefits analysis project is at its beginning stage in Argentina. In this preliminary report the methodological aspects of the project are described. The key element of the chosen approach are the emissions inventories estimation from GHG mitigation measures under analysis that could be implemented before 2012. The AirWare dispersion model will be used to obtain the concentration of PM, CO, NO_x, and SO_2 in the Buenos Aires Metropolitan Area. Health effects analysis and avoided health costs estimation procedures will be used to value the local health co-benefits of adopting climate change mitigation policies in Argentina.

INTRODUCTION

Goals and Rationale

- Assess and quantify the air pollution benefits of energy efficiency enhancement technologies that are identified as priorities for greenhouse gas mitigation policies.
- Demonstrate that the results of this analysis can promote support for the implementation of "win-win" measures and technologies to reduce greenhouse gas emissions, including implementation of technology cooperation agreements.
- Consolidate the capacity to conduct economic evaluation and risk assessments in relation to these issues.

Because Argentina has made significant efforts towards the effective reduction of emissions, it is very important to assess the potential benefits of GHG mitigation measures for Argentina. This will assist government officials and stakeholders to understand comprehensively the air pollution benefits of energy technologies that reduce greenhouse gas emissions, to build support for implementation of GHG mitigation measures, and enhance the capacity to conduct co-benefits analysis of GHG mitigation measures on an ongoing basis. These benefits will be additional to those resulting from climate change purposes and they will help to make evident another important point to take into consideration when planning mitigation measures.

Furthermore, as in fact Argentina has currently no other possibility to profit from the Kyoto mechanisms other than the Clean Development Mechanism, which consists solely in project activities offsets, clearly it has to explore the whole range of benefits derived from mitigation policies and measures. Because some of the benefits are not explicit, while all the costs are evident, if Argentina wishes to persist further in its goal of diminishing emissions intensity in the long run, it is necessary to take into account all benefits, direct or ancillary, including the ones under analysis, and quantify and value those benefits, so as to have a precise account of the net effect of these policies.

This study also gains in relevancy because the Greater Buenos Aires Metropolitan Area (BAMA) is one of the largest urban centers in South America. The population living in this area nowadays exceeds 14 million and the high population density, relatively high level of motor vehicle ownership, large number of old, smoky public transport vehicles, high concentration of truck traffic, and the industrial and thermoelectric complexes located there, all contribute to air and noise pollution levels.

The "good breezes", that originally gave the city its name, attest to the fact that local air pollution in Buenos Aires is not so critical as it is in other Latin American megacities such as Mexico, Santiago de Chile, or Sao Paulo.

However, the data available on air pollution levels in the Buenos Aires Metropolitan Area show that these levels exceed international norms and even Argentina's own standards for respirable particulate matter (PM), oxides of nitrogen (NO_x), carbon monoxide (CO), and possibly other pollutants (as SO_2 and Ozone[1]).

Relationship to Other Related Studies

There are several related studies relevant to and close to this project. The World Bank "Pollution Management Project" has had a co-benefits analysis to evaluate the advantages of implementing and installing a monitoring network for the city of Buenos Aires and its surroundings (Weaver and Balam, 1998.). The World Bank "Clean Air Initiative" also addresses the goal of improving the air quality standards for Buenos Aires (WB, 1998).

Argentina has also conducted national studies on GHG mitigation options (ARG/99/003, 1999). However, co-benefits analysis were not carried out as part of those studies.

Several State Secretariats have elaborated an study to support the conversion of public transportation from diesel oil to compressed natural gas (CNG) vehicles (see e.g., Barrera, Conte Grand, and Gaioli, 1999). Along these lines, several gas distributors have requested studies to different institutions –Fundación Bariloche (FB, 1999), Fundación Siglo XXI (SXXI, 1999), Estudio Alpha (ALPHA, 1999), etc.– to estimate air pollution benefits related to a greater penetration of CNG in the transportation sector. Fundación Ciudad (FC, 1999) has prepared an analysis on air and noise pollution in Buenos Aires city.

More recently, ENARGAS (the entity commissioned with the regulations on gas), is conducting, together with the Comisión Nacional de Energía Atómica (CNEA) and the institutional participation of the Secretariat of Sustainable Development and Environmental Policy, a comparative study including measurements of different vehicles technologies and fuels. This is in order to provide an adequate methodology to quantify environmental impacts and external costs and benefits of the different options.

Project Team

Experts and technicians from different institutions integrate the project team. Head of the project is Fabián Gaioli (Universidad Nacional del Sur and Secretariat of Sustainable Development and Environmental Policy), who leads a research group at the University. An expert designated by the Climate Change Unit of the Secretariat of Sustainable Development and Environmental Policy will be in charge of elaborating the first modules of the work, related to GHG mitigation scenarios development and baseline determination and emissions inventories and related data estimates, together with the head of the project. This task will be developed in collaboration with research associates, who will provide technical assistance and data gathering (information on the transport emissions, data on traffic, frequency and density of vehicles in the region of interest). The module on air pollution dispersion modeling will be developed by Ángel Capurro, from Universidad de Belgrano, a center of research and educational institution that has teams with expertise in mathematical modeling of environmental and biological systems. The health effects analysis will be made by Mariana Conte Grand, an environmental economist from

[1] In this analysis, ozone will be estimated from data on nitrogen oxides and volatile organic compounds, and total suspended particulate will be also considered to compare with PM.

Universidad del CEMA, in collaboration with a health expert to be confirmed. Conte Grand will carry out the economic valuation. Pablo Tarela from the Instituto Nacional del Agua y el Ambiente, Ministry of Infrastructure and Hector Collado, Secretariat of Transport of the Ministry of Economics will be working on emissions inventories and related data estimates. Finally, the benefits and policy analysis will be prepared together with an expert from the Climate Change Unit of the Secretariat of Sustainable Development and Environmental Policy. The head of the project will participate actively in all stages of the work and coordinate the flow of data and inputs from the diverse experts and modules.

METHODOLOGY

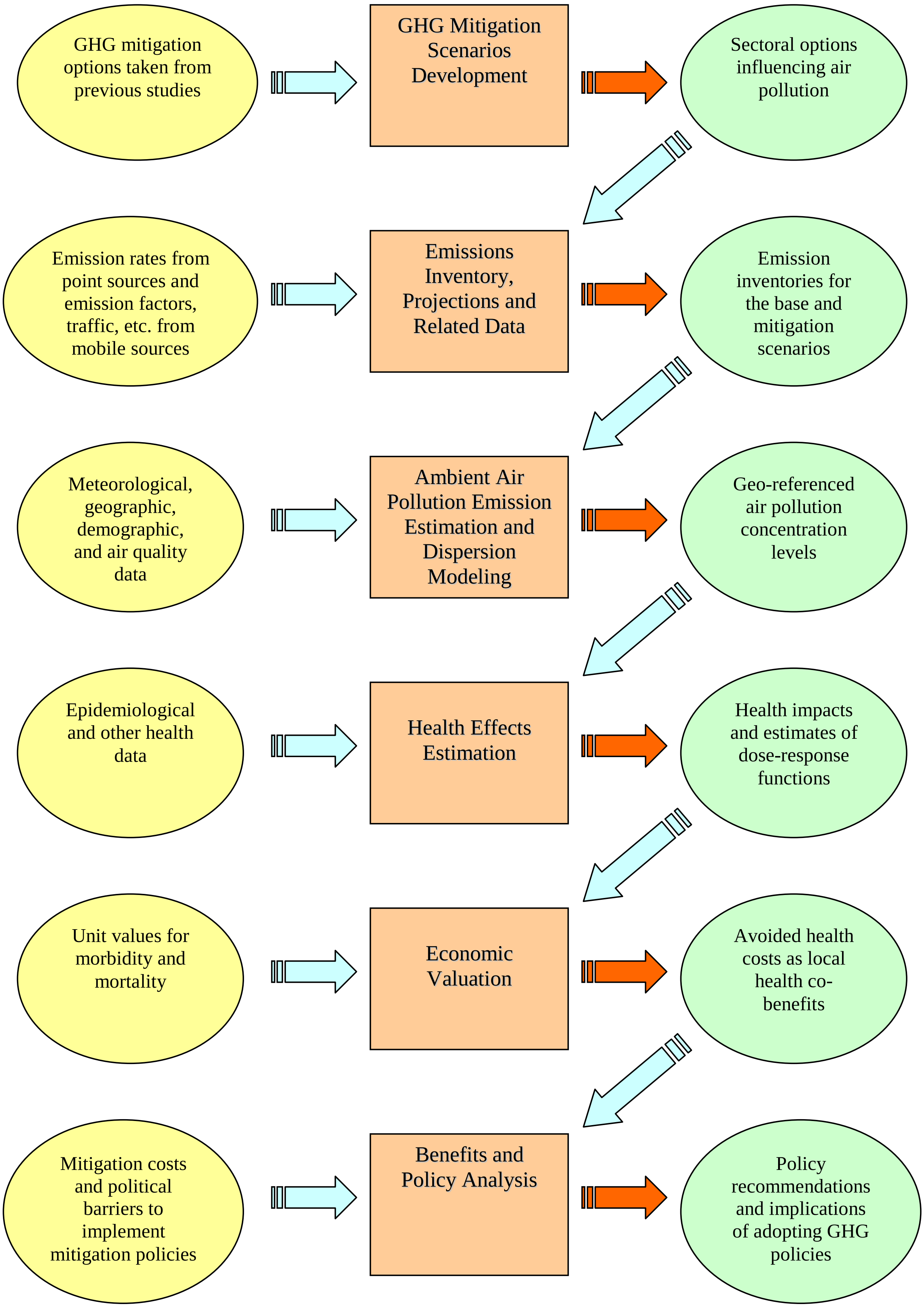
Overview

The project has six major activities: 1) GHG Mitigation Scenarios Development, 2) Emissions Inventory and Related Data, 3) Ambient Air Pollution Models, 4) Health Effects Estimation, 5) Economic Valuation, and 6) Benefits and Policy Analysis.

The work effort on GHG Mitigation Scenarios Development will analyze independently several mitigation measures that are likely to be serious options to be included in any GHG mitigation scenario for Argentina. Estimates of ambient air pollution resulting from the baseline and GHG mitigation scenarios will be prepared for each of the primary and secondary pollutants considered.

Current data in the BAMA and others cities will be obtained from the existing monitored levels of the main air pollutants. Ambient air quality scenarios will be developed mainly for the Buenos Aires Metropolitan Area. These scenarios will identify the main reductions in air pollutants and the size of those reductions.

The main outcome of the Health Effects Estimation will be the estimates of the changes in health effects resulting from reductions in ambient pollution levels of each of the pollutants. The methodology to be used in this case is the damage function approach. Analysis of the potential benefits involves the economic valuation of the health effects. The final activity is an analysis and integration of the entire assessment process. This activity will integrate the results from the previous five activities, to show the relevant aspects that can be useful for the formulation or revision of policies. The following flow chart diagram illustrates the major analytic components and the “inputs and outputs” of the project.


GHG mitigation options taken from previous studies
GHG Mitigation Scenarios Development
Sectoral options influencing air pollution
Emission rates from point sources and emission factors, traffic, etc. from mobile sources
Emissions Inventory, Projections and Related Data
Emission inventories for the base and mitigation scenarios
Meteorological, geographic, demographic, and air quality data
Ambient Air Pollution Emission Estimation and Dispersion Modeling
Geo-referenced air pollution concentration levels
Epidemiological and other health data
Health Effects Estimation
Health impacts and estimates of dose-response functions
Unit values for morbidity and mortality
Economic Valuation
Avoided health costs as local health co-benefits
Mitigation costs and political barriers to implement mitigation policies
Benefits and Policy Analysis
Policy recommendations and implications of adopting GHG policies

Key Scoping Decisions

A first in-country scoping meeting was held in Buenos Aires city in September 22, 1999. It included the participation of around forty experts from the public and private sectors, NGOs, and academics and consultants. It was organized by the Secretariat of Sustainable Development and Environmental Policy and involved experts from the Secretariat of Transportation, the Government of the City of Buenos Aires, Secretariat of Environmental Policy of the Government of the Province of Buenos Aires, the Ministry of Health, Instituto Nacional del Agua y el Ambiente (INA), Universidad de Buenos Aires (UBA), Universidad del CEMA, Universidad de Belgrano (UB), the Argentine Society of Environmental Medicine, Fundación Bariloche, National Commission on Nuclear Energy (CNEA), National Institute of Industrial Technology (INTI), Argentine Association of Sanitary Engineering and Environmental Sciences, the Laboratory of Atmospheric Control, National Institute of Agricultural Technology (INTA), many environmental NGOs, and the special participation of experts from the U.S. Environmental Protection Agency (EPA), the National Renewable Energy Laboratory (NREL), the World Bank, and Abt Associates.

The workshop was useful to define the objectives of the analysis and the pollutants of interest, and contributed to pave the way to constitute the expert team for the project. It also helped to identify the available data, previous works in the field, and a review of the main mitigation options.

- The geographic scope is restricted to the Buenos Aires Metropolitan Area –inhabited by 30% of the Argentinean population–, which comprises the Federal Capital District (administered by the autonomous Government of the City of Buenos Aires) and some 20 Municipalities of the surrounding Province of Buenos Aires (called Greater Buenos Aires). The Río de la Plata bounds the BAMA on the Northeast, which near Buenos Aires is more than forty kilometers in width. On workable days there is a flux of around 6 million commuters going from the Greater Buenos Aires to the city early in the morning and coming back home at night. That gives a clear picture of the daily traffic associated to such a flow. The study will extend the results from BAMA to assess the impacts of GHG mitigation options for the rest of the main urban areas in the country (tentatively, Greater Córdoba, Rosario, Mendoza, Tucumán, and/or Bahía Blanca; cities chosen due to their high population and traffic).
- The sectors to be considered in the project will be electric generation, transportation, fuel distribution, industry, and waste management. The rest of the sectors, such as the agricultural one, have a very low impact on the air pollution levels in the area of study.
- The pollutants selected were those which have the major impact on the health of the exposed population and that are probably exceeding the actual air quality standards. Specifically they are particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and ozone.
- The different pollutants have different associated health effects to be taken into account. In general, the health effects selected for analysis are all those that causes premature deaths, respiratory hospital admissions, emergency room visits, restricted activity days in adults, asthma attacks, lower respiratory illness in children, respiratory symptoms in adults and eye irritation.
- The economic valuation will take into account the unit values for mortality and morbidity. The social benefits result from the difference in damages from the mitigation scenarios and the base case. Health benefits require the use of unit economic values such as the *value of a statistical life* (to approximate the value of a statistical life lost as a consequence of pollution), direct costs of illness or *medical costs* (derived from those people who suffer some related illness), loss of *wages* (for full or partial days people do not work as a

consequence of pollution, which constitute indirect cost of illness), and, then, to compare the value of *individuals' "willingness to pay" –WTP– to avoid symptoms caused by pollution* (e.g., eye irritation or cough). Some of those unit values are calculated from national information, others (like WTP to avoid symptoms) are U.S. estimates adjusted by the ratio of Argentina to U.S. wages, or GDP per capita, or a related correction factor (i.e., the ratio or Argentina/U.S. medical costs or doctor visits' costs, or the WTP-Income elasticity).

- ❖ An integration of the entire analysis process will be carried out in order to show the relevant aspects that can be useful for the formulation or revision of GHG mitigation policies. The comparison between avoided health costs and the costs and benefits of mitigation options through opportunities and investments for the private sector and stakeholders will be presented to policy makers.

Design of Baselines and Scenarios

A national study was elaborated in 1999 (ARG/99/003, 1999) in which the 1997 GHG inventory, macroeconomic and sectoral projections for the period 1999-2012 in order to establish the baseline scenario were performed, and several GHG abatement measures that define a set of mitigation scenarios were identified.

Macroeconomic Projections

Four research centers were commissioned to carry out studies to develop macroeconomic projections. Due to the great uncertainty implicit in the projections of economic growth for a developing country with a growth path such as Argentina, each of the studies developed three different scenarios: a medium scenario and two alternative high and low scenarios. The macroeconomic projections included economic evolution parameters of the international economy, among them: Gross Domestic Product (GDP) growth rates for countries with which Argentina is commercially related, prices, exchange rates and international rates of interest. As regards Argentina's economy, the following five types of indicators were considered: 1) Total and per capita GDP at market prices; 2) Macroeconomic aggregates: Consumption, Investment, Exports, and Imports; 3) Sectoral GDP (one or more digits with the Uniform International Industrial Classification, UIIC); 4) Prices, Exchange Rate, Rates of Interest, and 5) Evolution of the labor market. The results thus obtained supplied a range of possible trends of the Argentine economy from 1999 until 2012 (projected on an annual basis, in every case).

Sectoral Analysis

As has been evidenced by the 1990 and 1994 inventories, and verified in the 1997 inventory of Argentine GHG emissions, GHG emissions originate mainly in the energy sector (including transport) and through Agricultural Production.

The LEAP simulation model was used in the energy and transport sectors, and both macroeconomic projections and projections of stocks and exports supplied by the Secretariat for Energy were taken into account. In all cases, the baseline scenarios contemplated an enhanced efficiency derived from the incorporation of the most adequate technologies introduced as a consequence of the operation on market forces.

Thus, for electricity generation, it is assumed that the new generating equipment, or the replacements due to obsolescence, will use mainly natural gas in a combined cycle. Furthermore, in some cases such as transport, the emissions scenarios have been calculated taking into consideration some technological improvements expected to be incorporated before or during the projection period.

An OECD model, adapted to Argentina, was used in the simulation of the Agriculture and Livestock sector as a whole. This model considers agriculture and livestock-related prices and the levels of efficiency of the production systems. A distinctive characteristic of the Argentine Agriculture and Livestock sector is its fast response to prices, fundamentally to international ones. This leads to a significant portion of the land with agricultural potential to be used alternately in agricultural or livestock-producing activities.

In the Solid Waste Management Sector a linear regression model, based on per capita GDP, was used. Data was supplied by The Great Buenos Aires Agency for Garbage Collection and Disposal and other agencies in charge of the disposal of solid waste. The historical adjustment of that regression is very good, for which reason its utilization in future projections was considered adequate.

Mitigation Options

Argentina has been making substantial efforts towards the reduction of GHG emissions since the seventies, implementing policies based on opening and deregulating the economy, mainly but not only, by means of huge investments in hydroelectric generation, the substitution of oil by gas in energy power plants, the conversion to natural gas in vehicles and, more recently, the promotion of wind and solar energies. All those actions have favored the unilateral mitigation of GHG emissions by means of the incorporation of efficient technology (for example, in the thermoelectric market). Other direct policies have also been implemented by means of concrete regulations and subsidies with private or fiscal costs (for example, regulations to reduce fugitive methane emissions as a consequence of flaring in oil production and subsidies for forestry).

The most important mitigation measures were selected according to their scale and feasibility. They are:

a) Energy Sector

Hydroelectricity: Each of the hydroelectric projects for which there were available studies permitting an estimation of their mitigation costs has been examined. Most of them have burdensome incremental costs for carbon emissions reductions (since it is valued with respect to its opportunity cost, that is, with reference to the baseline scenario in which energy is produced with natural gas combined cycle equipment).

Wind Energy: Argentina's potential capacity to produce wind-energy is equal to several times the total installed capacity for the generation of electric power in the country. Nevertheless, for several reasons, one of which is the cost, the use of this resource is at present still marginal. Nevertheless, there are both national and provincial laws that include fiscal incentives to promote its use.

Co-generation: This option offers an important possibility of mitigation in industrial activities with additional benefits derived from fuel savings and less local contamination.

Fugitive emissions: the Secretariat of Energy has determined that there should be a progressive reduction of natural gas emissions from flaring in oil wells. Thus, this is again an example of policies adopted to reduce GHG, which will have been having an impact in terms of actual emissions.

Transport (substitution of energy sources): An analysis was made of the greater penetration of natural gas in transport. More specifically, in private vehicles, and above all in urban public passengers transport and in light duty trucks.

b) Agriculture Sector

Crops: The analysis was focused on the possibility of introducing “low tillage” or even “no tillage” (commonly known as direct sowing). These practices can lead to less fuel consumption in agricultural labor. Direct sowing can also have a high positive impact on soil conservation (producing carbon sequestration).

Livestock: The mitigation measure considered is that of a greater efficiency of the sector by shortening the production cycle, with better feeding and different practices, and perhaps an increase in the percentage of animals in feedlot.

c) Forestry

In the case of the forestry sector, Argentina follows active policies with explicit fiscal costs (government subsidies) that are contributing to increase the stock of carbon stored in commercial plantations. There is an existing legislation on the matter, which means the persistence of this policy in the long term. Therefore, the increase of carbon stocks in forest plantations should be considered as a mitigation option.

d) Solid Waste Sector

Methane emissions of landfills can be burned, avoiding the greenhouse effect of this gas, which is much greater than that of carbon dioxide which takes place in methane combustion. Until 1997 landfills were only done with the wastes of the Buenos Aires Metropolitan Area, but this practice could be extended in the near future to at least another six big cities. The use of methane emanations from sanitary fillings in power generation is another possibility.

The following table shows the aggregate emissions of all GHG in million tons of Carbon equivalent for the base scenario, restricted specifically to the sectors influencing local air pollution. The information related of emissions by sources and categories is also available.

Sectoral Greenhouse Gas Emissions for Argentina (in Millions of Tons of Carbon Equivalents)

Sector	*1990*	*1994*	*1997*	*Average for 2008-2012 Low-growth*	*Average for 2008-2012 Medium-growth*	*Average for 2008-2012 High-growth*
ENERGY	30,1	34,9	38,2	52,3	59,2	69,1
Combustion	26,2	30,1	33,1	46,2	52,3	61,2
Fugitive Emissions	3,9	4,8	5,1	6,1	6,9	7,9
INDUSTRIAL PROCESSES	1,6	1,7	2,5	2,8	4,0	4,0
WASTE MANAGEMENT	2,5	4,1	4,4	5,9	6,6	7,5
TOTAL	**34,2**	**40,7**	**45,1**	**61,0**	**69,8**	**80,6**

Estimating Air Pollution and GHG Emission Levels and Developing Emission Inventories

The GHG considered in this analysis are all GHG included in Annex A of the Kyoto Protocol: carbon dioxide, methane, nitrous oxide, HFC, PFC, sulfur exafluoride, and also data on CFC were considered. In the referred ARG/99/003 study (1999) some pollutants were taken into account in some cases, such as carbon monoxide and nitrogen oxides.

As it was already mentioned above, carbon monoxide, particulate matter, nitrogen oxides, and sulfur dioxide are the primary air pollutants that will be considered in this study. They are the pollutants on which there are data to calibrate the air pollution models and which, as it has already been said, sometimes exceed the air quality standards.

As is evident from the previous section, only some emission sectors are altogether relevant for local air pollution, such as transport, thermal power plants close or in the region of interest, waste management in a minor level of importance, and a minor influence by certain industries (this sector contributes with a very little amount of total GHG emissions). In that regard the following methodology will be implemented.

Since the mitigation options considered in ARG/99/003 (1999) are those that represent the largest emissions reduction and no great attention[2] has been given neither to spatial distribution nor to the small contributions coming from particular sources, we will extend the analysis to the mitigation options that can be implemented at a local level, having influence on local air pollution. Therefore we will consider transport, thermoelectric generation and industry options in more detail. In that case we will consider the information on the greater penetration of natural gas in transport and eventual modes substitution, the fugitive emissions originated in the distribution and load of natural gas and fuels, the conversion to combined cycle in power plants and energy co-generation in industrial activities. A certain degree of analysis of the impact of waste management will also be performed.

After finishing this prior analysis, instead of considering the proportion of pollutants emissions reduction from the reduction in GHG emissions, the levels of pollutants emissions from specific data and pollutant emission factors will be estimated. In the case of transport, the specific data will be mainly obtained from information and databases of the Secretariat of Transportation and the Government of the City of Buenos Aires, such as traffic data, the number and kind of vehicles traveling daily around the city, their frequency, etc. Data on emission factors, by technology and fuel use, will be provided by the laboratory of emissions control of the INA, from direct measurements –using the US IM240 test for Otto cycle vehicles– of the present and foreseen automobile sector dimensions. A similar approach will be used for the other sectors and is going to be applied, when possible, to the rest of the country. These data will allow obtaining the pollutants inventories for the base and the mitigation scenarios.

Assumptions about energy policies and technology deployment have already been considered in ARG/99/003 (1999) and assumptions about air pollution controls will be made taking into account the World Bank programs on “Pollution Management” and “Clean Air Initiative” for the city of Buenos Aires and surroundings.

[2]The studies of the consultants on different sectors have considered more detailed information, which will serve as a basis for our analysis. However, some of the information needed will be obtained and developed by the team working on this project.

Air Pollution Dispersion Modeling to Estimate Air Pollutant Concentrations and Exposure Levels

Air pollution levels in the City of Buenos Aires

Monitoring of air quality in the City of Buenos Aires and in the Buenos Aires Metropolitan Area has been rare and sporadic. Therefore, no reliable information exists of the current main sources of pollution neither of which are the most common contaminants and their concentrations (WHO, 1992). It is assumed here that the City of Buenos Aires presents the same characteristics as other megacities of the world, being auto-transport the main source of pollution. High concentrations for CO, O_3, particulate matter, NO_x and SO_x may be then expected.

Thanks to its geographical and climatic conditions, the situation of Buenos Aires is not as critical as in other megacities. There are long-term data series for 1968-1973 from six stations (REDPANAIRE, OMS, 1974). The concentrations of SPM (suspended particulate matter) and SO_2 were within the WHO guidelines, except for some extreme daily means. In 1985 and 1986, the GEMS (Global Environmental Monitoring System, WHO) measured concentration of suspended particles in two locations in the city. For some of the measurements the average and the daily maximum concentrations exceeded the WHO guidelines.

A study of air pollution from auto-transportation was made between 1974 and 1977. Only 20 different sites were used for the 4 campaigns, half of them with heavy traffic. It was concluded that average concentrations for CO, SO_2 y NO_x in the centric area were significantly higher than those found in the industrial area. Regarding oxidants and O_3 the average concentrations were significantly greater for the industrial area than for the centric area. Caridi et al. (1989) found out that typical concentration for Pb in the suburban areas was 0.3 g/m^3 and 3.9 g/m^3 in centric areas of the city. The average time of sampling is not specified. In 1994, sampling was made in 19 stations for NO_x and SO_2 in the city, between May 25 and July 13 (Aramendía et al., 1995).

NO_x concentrations varied between 0.027 ppm and 0.047 ppm, and for SO_2, between 0.002 ppm y 0.008 ppm. The higher values correspond to centric area, but are below the maximum tolerable limits established by EPA (Environmental Protection Agency, USA). No significant seasonal variations were noticed. The method used concealed the presence of peaks. Air was sampled for aerosols in the centric area. In 15% of the few samples taken the amount was higher than acceptable, according to limits established by EPA.

Currently, there is one monitoring station located in the centric area of the city that measures only CO. The curve of the daily variation of CO concentration shows the maximum peaks, corresponding to morning and evening rush hours. The greatest peak is the one registered between 8:00 and 11:00 a.m. with concentrations between 11.0 and 17.00 ppm, while during weekends and holidays it decreases to 1.0 to 4.0 ppm (La Nación, 1994-1995). The WHO guidelines recommend 9 ppm as maximum CO concentration for 8 hours exposure.

The Municipal government has a station in another site where average concentrations of NO_x, SO_2 and particles do not exceed the limits of 0.1 mg/m3, 0.07 mg/m^3 and 0.150 mg/m^3 respectively, established by local legislation for long periods of time.

Dispersion Model

The AIRWARE model is used. Environmental Software and Services company (ESS) from Austria developed this software. It was adapted to Buenos Aires City by a team of the

Universidad de Belgrano and ESS, while the GAIA Project, granted by International Cooperation Program from European Union, was being realized during 1995-1998.

The AirWare system provides an integrated framework for easy access to advanced tools of data analysis and the design and evaluation of air quality control strategies. AirWare combines: a) integrated data base management for emission inventories and meteorological and air quality data, b) a set of simulation and optimization models for strategic analysis, optimization, and operational forecasting, together with c) a geographic information system, and d) embedded expert systems functionality, and assessment functions.

AirWare Requires the Following Basic Data Sets

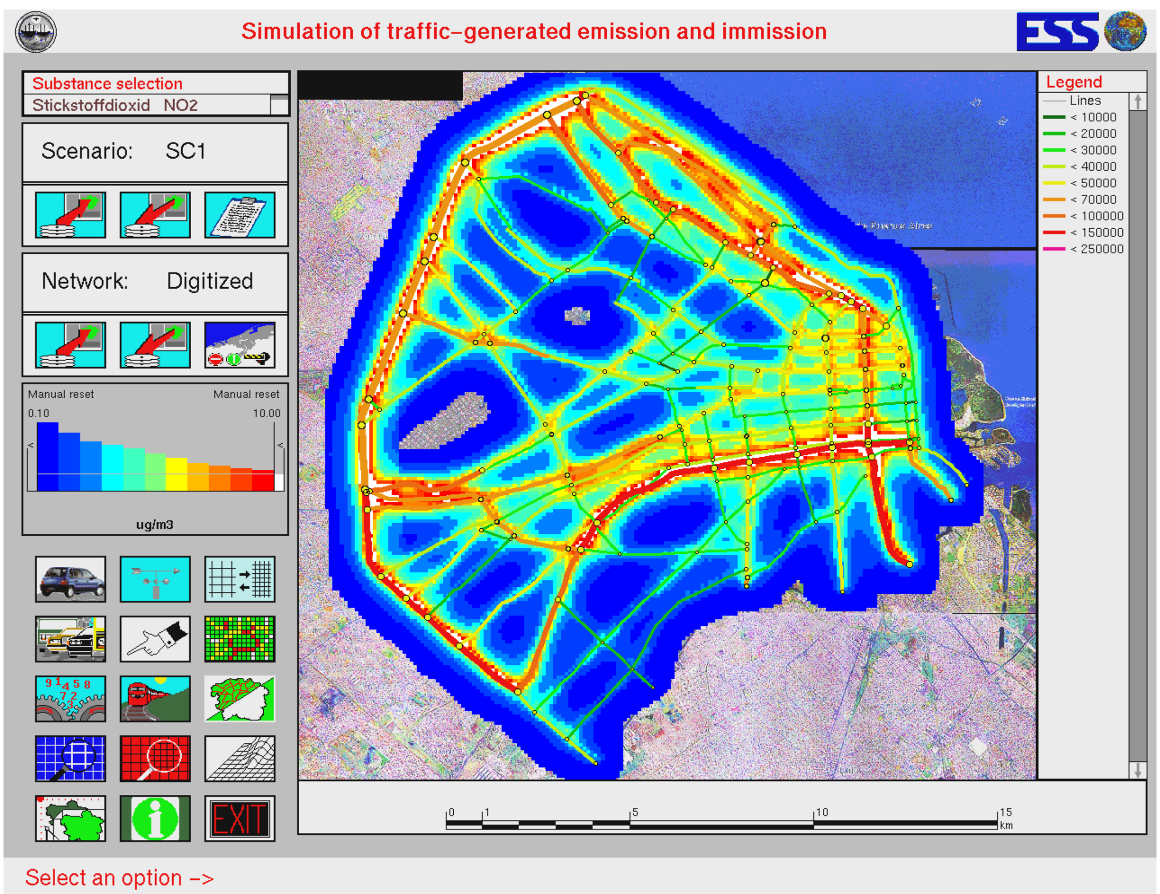
Geographical Data	Background maps with administrative boundaries, land use; satellite data or aerial photography and scanned maps can be used together with vector maps; digital elevation model (DEM) for complex terrain; the system can import data from all common GIS and IP systems; road network (geometry) graph for traffic emission/immission model.
Population Data	Gridded (usually by hectare) or associated with building block boundaries required for exposure assessment.
Emission Inventories	**Point sources** (major industries, power plants): location, emission rates, stack height; industry background data, production and energy use data, stack diameter, emission temperature and velocity. **area sources (**domestic, air ports, industrial estates): location (gridded or set of polygons, emission rate, height). **line sources (traffic):** road segment attributes like traffic density, frequency or direct emission data.
Meteorological Data	Time-series of basic meteorological data (half hourly or hourly, covering at least one year or the period of interest for the long-term models): wind direction and speed, air temperature, mixing height, stability class, precipitation. Mixing height and stability class can be estimated, if necessary, using cloud cover and/or solar radiation data; the system can be linked to on-line monitoring networks.
Air Quality Data	Hourly or half-hourly observation data from one or more observation stations; station location and regular time series for each parameter.
Economic Data	Discrete cost functions (investment and operational costs, social costs where applicable) for a set of alternative emission reduction and control strategies for each emission source to be considered.

One of the central models in the AirWare air quality management information system is the Industrial Source Complex Model (ISC-3). ICS-3 is a multiple point sources and area source model developed by the US Environmental Protection Agency, EPA. It is a Gaussian plume model that can describe individual episodes of a few hours or long-term, e.g., annual, average conditions. A basic assumption of the Gaussian model is steady-state conditions, i.e., both the emissions and the weather conditions in terms of wind speed, directions, air temperature, stability class, mixing height, and precipitation, are assumed constant. ISC has been specifically developed to simulate air pollution due to the operation of an industrial plant, taking accurately into account the effect of high stacks on the behavior of the pollutant plume. It may be applied in urban or rural environment with a moderately complex terrain. Its numerous options allow computing the dry deposition of the pollutant downwind the stacks, to model the plume height accounting for the hydrodynamical effects, to simulate the impact of linear, area and volumetric sources. It works with non-reactive pollutants, including particulate matter, but may include a first order decay.

The program has two versions. In the long term version (ISC-LT), it computes average concentration values on an area of few hundred square kilometers for a period like a season or a year, on the basis of the correspondent meteorological data. The short-term version (ISC-ST) computes mean concentration values for a period of one or few hours.

BAMA does not yet have a monitoring network. The data collected by the isolated stations mentioned above will be used to calibrate the air pollution model.

Example of the AirWare Outputs for the Case of the Main Avenues of Buenos Aires City (immission levels of NO_2)



Health Effects Analysis

Usual “avoided health costs” procedures will be used to value the local health co-benefits of adopting climate change mitigation policies in Argentina[3]. The work will begin more specifically in the Buenos Aires Metropolitan Area (BAMA). The main precedent for this task being the results obtained under the World Bank “Pollution Management Project” (Conte Grand, 1998).

The basis to perform this analysis are the result from Task E. This means that there must be an evaluation of air quality changes in each cell of the grid chosen for the BAMA due to the different climate change mitigation options, measured by PM_{10} –or $PM_{2.5}$–, SO_2, Ozone, NO_2, and CO.[4] For the valuation exercise (tasks F and G), the general methodology can be summarized in three steps:

1) Obtain basic estimates for the relevant region. Two kinds of information are needed:

    a. *Demographic data (mortality rate, number of adults, and number of children) for each cell of the grid, and number of asthmatics.* Those data are used as an input in the so called “dose-response functions” (which measure the impact of pollution indicators on health), and

    b. *Other information as hospital admissions or emergency room visits, the number of symptoms (cough,, chest discomfort, or eye irritation) caused by pollution,, as well as the working population*. If there are no epidemiological studies linking air pollution and health, as is the case for Argentina[5], these data are only used to check the reasonability of the calculated total health impacts.

2) Given the basic indicators and the goal of pollution reduction, quantify the health impact using the corresponding dose-response functions[6]. While it would be ideal to estimate such functions for each country, the lack of resources and information (particularly epidemiological studies) makes it necessary to use coefficients estimated for other countries

---

[3] Valuing health effects consist in assigning a monetary value to deaths, illnesses, days not worked and any other consequence on health due to a particular pollution action. For example, the U.S. EPA uses “avoided health costs” as a way of valuing environmental benefits to determine their air quality standards (see US-EPA, 1996a and 1996b). In addition, several World Bank studies have already used “avoided costs” as a measure of the benefits of reducing urban air pollution (see, for example, WB, 1994a and WB, 1994c). In the same line, more recently, a meta-analysis to value the social cost of fuels was performed by Maddison et al. (1997) for eight developing countries cities. Most of those valuation exercises are based on a review of international literature on health effects of pollution by B. Ostro with an application of the resulting “dose-response functions” to the case of Jakarta (WB, 1994b). There are also numerous other epidemiological studies both in the U.S., Canada, Europe and in other Latin American cities (in that respect, see Ostro, Sánchez, Aranda, and Eskeland, 1996 or Cifuentes and Vega for Chile, Loomis, Castillejos, Gold, Donnell, and Borja-Aburto, 1999 for Mexico, and Seroa da Motta and Mendes, 1996 for Brazil).

[4] Note that while lead has a strong impact on people’s health, no impact is accounted in BAMA because Argentina has completely shifted to unleaded gasoline.

[5] Dose-response functions with local data do not exist in Argentina. For example, two papers (Bertello, 1991 and 1996) link lead and mercury exposure and health, but all their bibliographic references are foreign. However, there is some data gathering at the Jefatura de Gabinete de Ministros, whose results are not public yet.

[6] Pollution is said to cause negligible health impacts if air quality meets the standards. Then, if measured pollution is lower than the standard, health effects of improving air quality must be considered null. According to Weaver and Balam (1998), this is the case for PM_{10}, NO_2, and CO (and few days O_3) in BAMA.

as approximations for the health benefits of reducing pollution. Then, by knowing, for example, that a reduction of 10 $\mu g/m^3$ in annual average PM_{10} concentrations decreases mortality approximately by 1%, it is possible to approximate the number of people whose death due to air pollution will be averted if such policy goal is achieved.

3) Convert health data to economic values. This requires: *a) for mortality*, the use of unit economic values as the *value of a statistical life* (to approximate the value of a statistical life lost as a consequence of pollution), and *b) for morbidity*: direct costs of illness or *medical costs* (caused by those people who suffer some related illness), loss of wages (for full or partial days people do not work as a consequence of pollution, which constitute an indirect cost of illness), and the value of *individuals' "willingness to pay" to avoid symptoms caused by pollution* (e.g., eye irritation or cough). Some of those unit values can be calculated from national information, others (basically, WTP to avoid symptoms) are simply approximated by U.S. estimates adjusted by the ratio of Argentina to U.S. wages, or GDP per capita, or a related correction factor (i.e., the ratio or Argentina/U.S. medical costs or doctor visits' costs, or the WTP-Income elasticity).

The absence of good information for each of those four steps implies that some assumptions have to be made to obtain approximations to the benefits of reducing pollution. Lower and upper bounds both for health impacts and for unit values are defined as a way of establishing ranges of possible benefits.

Health Impacts

The health impacts to consider will be those whose dose-response functions are reported and used for eight developing countries cities in Maddison et al (1997), including the following:

PM
All-causes Premature Deaths
Respiratory Hospital Admissions
Emergency Room Visits
Restricted Activity Days adults
Asthma Attacks
Lower Respiratory Illness in children
Respiratory symptoms adults
Chronic Bronchitis adults

NITROGEN DIOXIDE
All-causes Premature Deaths
Respiratory Hospital Admissions

SULFUR DIOXIDE
All-cause Premature Deaths
Respiratory Hospital Admissions
Cough days children
Chest discomfort days adults

OZONE
All-cause Premature Deaths
Respiratory Hospital Admissions
Minor Restrictions in Activity Days adults
Upper and Lower Respiratory symptoms days adults
Asthma Attacks
Eye irritation adults

Dose-response coefficients will be then checked with epidemiological studies for Mexico, Chile and Brazil (cited in footnote 1) as a way to foresee possible differences in Argentina with other Latin American countries. Finally, there will be a review of literature on the relationships between health and pollution for CO will be made to include that end-point. PM2.5 estimates will also be added because of the high impact they have on health.

Economic Valuation

In order to perform the economic valuation we need to know first the unit cost values to translate health impacts into economic values.

a. Unit Values for Mortality (the Value of a Statistical Life)

There are several alternative methods on how to calculate the value of a statistical life. The most well known are the ones related to WTP a given mortality risk and the Human Capital approach. The latter is a lower bound of the former since it uses foregone future incomes as the valuation vehicle, which does not include the subjective value people assign to life.

❖ ***Indirect Method to Value WTP***

This measure requires knowing the wage differential for risky activities and the associated risk (the proportion of in-the-job deaths for those workers exposed to risk). Usually, that estimation is derived from information for particularly risky jobs as in the construction sector. Both the numerator and denominator of this measure are difficult (but not impossible) to obtain for Argentina. In Argentina, some "Convenciones Colectivas de Trabajo" (as the one for construction workers) have provisions on wage differentials for unhealthy and risky tasks. On the other side, the Labor Risks Act (Act No. 24,557/95) obliges the Superintendencia de Riesgos del Trabajo (SRT) to keep a record on labor accidents (http://www.srt.gov.ar/publicaciones/sinies98/sinifram.htm).

❖ ***Human Capital Approach***

This approach values mortality by the loss of "productive" days due to premature death, and hence the net present value of income lost. Information on wages lost and life expectancy is available at the Instituto Nacional de Estadísticas y Censos (INDEC). On the other side, there is an "official value": a maximum value assigned to a life under the Argentine Labor Risks Act (which is $110,000).

Other alternatives to value WTP for BAMA imply taking the US estimation of $6 million dollars of 1990 (around $4 million dollars of 1993 for OECD countries), and adjust it to match the value of a life in Argentina. One possibility is to use as the adjustment factor the proportion of Argentina and US GNP per capita. Additionally, one can make a correction by taking into account the WTP-income elasticity to capture the fact that different levels of income change the amount that people are willing to pay (as in WB, 1994a and Maddison et al., 1997). Finally, there is strong evidence of an inverted-U relationship among WTP and income (Jones-Lee et al., 1985), meaning that the WTP is relatively lower at the beginning and at the end of life. This fact influences the unit value for a statistical life (VOSL). Then, it is reasonable to adjust the WTP estimations by that fact, as suggested by Maddison et al. (1997). Since people over age 65 have WTPs of 75% of the WTP for the mean population and, at the same time, they represent 85% of those who die from air pollution, the value of a statistical life can be derived from the following equation: $(0.85 \cdot 0.75) \cdot \mathrm{VOSL} + 0.15 \cdot \mathrm{VOSL} = 0.7875 \cdot \mathrm{VOSL}$. All those calculations will be undertaken by employing Argentina information in order to have a range of possible values of life.

b. Unit Values for Morbidity[7]

- ***Costs of Illness (COI) Approach***

  <u>Direct (Medical) Costs</u>

  - The easiest way to value "avoided medical costs" would be to have information on medical costs per day of the related (respiratory and circulatory) hospitalizations, average length of stay in hospitals due to pollution-related illnesses and costs of emergency room visits in Argentina. However, such information is not available except perhaps at the level of each hospital[8].

  - An indirect way to approximate a medical cost estimate for Argentina is to take the US figures and then adjust them by the ratio of the two countries' doctor visits costs (this constitutes the central bound for the medical costs estimates). For Argentina, there are two sources for that information (MSyAS, 1994 and 1996)[9]. An alternative is to adjust the US medical costs by the ratio of household expenditures on medical services in both countries. This way of making the adjustment incorporates differences in price and coefficients of utilization among both countries (it constitutes the upper bound for the medical costs estimates).

The costs of illnesses includes medical costs but also lost output due to the different illnesses:

  <u>Indirect (Lost Work Days) Costs</u>

  - Complete lost days can be value at the average monthly wage for Argentina (INDEC).

  - Minor restrictions in activity days can be valued at 60% of wages, since according to Maddison et al. (1997), only 40% of ill days are spend in bed, so the rest of the times people perform are able to perform some task.

- ***WTP Approach***

  Alternatively, since the COI approach includes medical costs and products lost but it does not include the disutility illnesses generate to people affected, some studies attempted to calculate WTP to avoid Respiratory Hospital Admissions, Emergency Room Visits, Lost Work Days and Minor Restrictions in Activity Days[10]. Usually, COI estimates are expected to be lower than WTP estimates, but that is not always the case. Here, as in the eight cities' study (Maddison et al., 1997), the WTP (average of WTP adjusted by wage or GDP ratio and

[7] This section has information available by 1998, but it will be updated to 2000. However, since many "field trips" to the different Ministries have to be made because almost no data of this kind is available on Internet, this work has not yet be performed under ICAP.

[8] There is though information on average length of stay for *all* illnesses in Argentinean public hospitals (MSyAS, 1996, and MSPBA, 1993) for Capital Federal (15 days), and for Conurbano (8 days).

[9] According to MSyAS (1994), the average doctor visits per person per month are 0.62 for Capital Federal and 0.56 for Conurbano Bonaerense. Then, by MsyAS (1996), doctor visits expenditures are approximately $13.94 and $26.77 millions per month for Capital federal and Conurbano respectively, and the population who goes to the doctor per month is 1,16 and 2,64 millions for Capital federal and Conurbano respectively. Then, dividing expenditures by the number of doctor visits yields $18 and $19 per doctor's visit for Capital federal and Conurbano respectively.

[10] As is very well pointed out by Cropper (2000), the Cost of Illness (COI) includes the change in expenditures in medical care and the value of income lost while ill, while in fact, the overall WTP also should include the disutility of time spent ill and change in expenditures on averting behavior. However, this last item is very difficult to estimate and so will not be considered in this study.

elasticity) is lower than COI (except for Emergency Room visits) and so is used as the lower bound. There are some studies on WTP to avoid the symptoms of those illnesses even if they do not result in days lost, emergency doctor visits or hospitalizations.

There are no approximations to WTP to avoid the different symptoms related to pollution for Argentina (and even less for the BAMA). Furthermore, there is a certain paucity of morbidity unit values at the international level. The WB Thailand valuation (WB, 1994a) and the US-EPA RIA PM paper report some of those unit values. However, a complete listing of them is only available from Maddison et al. (1997). Those estimates can be adjusted by the ratio of Argentina/U.S. GNP per capita or wage, or the WTP-income elasticity, and eventually by the age profile.

Then, the "avoided health impacts" times their economic unit value yield the benefits of each one of the climate change mitigation policies to be evaluated. The consultant will integrate all calculations in an Excel file in such a way as to make feasible the evaluation of any policy, once one knows its health impact. Data are expected to be aggregated at the neighborhood level for the Metropolitan Area of Buenos Aires, and values will be annual.

Policy Analysis

The first scoping meeting counted with the presence of several public institutions interested in the formulation of policies that contribute to climate change mitigation. The clean growth performance of Argentina can be strengthened with the availability of co-benefits studies as a means to more informed public decision-making.

The final activity is the analysis and integration of the entire assessment process. This activity will integrate the results from the previous activities, to show those issues that can be useful for the formulation or revision of policies.

SCHEDULE OF KEY ACTIVITIES

Activity	Sept. 99	Sept. 00	Oct. 00	Nov. 00	Dec. 00	Jan. 01	Feb. 01	Mar. 01	Apr. 01	May 01	June 01
First scoping meeting											
Project proposal											
Project Work Plan											
Baseline and Draf Scenarios											
Draft and Final Scenarios											
Draft and Final Report											
Final Report											
Follow-on Activity Report											

Note: Section III.E of this report was written by Ángel Capurro and Mariana Conte Grand wrote sections III.F and III.G.7

References

Aramendía, P.F., Fernández Prini, R., Gordillo, G. (1995), ¿Buenos Aires en Buenos Aires?, *Ciencia Hoy* 6 (31): 55-64.

ARG/99/003 (1999), Proyecto PNUD/ARG/99/003, "Inventario de Gases de Efecto Invernadero de la República Argentina" and "Revision of the First National Communication, Argentine Republic".

Barrera, D.F., Conte Grand, M., and Gaioli, F.H. (1999), "Análisis de la conversión a GNC del transporte público de pasajeros y de carga en el Área Metropolitana de Buenos Aires", SRNyDS, mimeo.

Bertello, L.F. (1991), "Oligoelementos en Clínica –II- Plomo", *Revista de la Asociación Médica Argentina*, Vol.104, No.9,10,11,12.

Bertello, L.F. (1996), "Oligoelementos en Clínica –II- Mercurio", *Revista de la Asociación Médica Argentina*, Vol.109, No.1.

Caridi, A., Kreiner, A.J., Davidson, J., Davidson, M., Debray, M., Hojman, D., and Santos, D. (1989), Determination of Atmospheric Lead Pollution of Automotive Origin, *Atmospheric Environment* 23, 2855-2856.

Cifuentes Luis, A., Vega, J., and Lave, L. (1999), "Daily Mortality by Cause and Socio-Economic Status in Santiago Chile", *Epidemiology, Supplement*, 10:S45.

Conte Grand, M. (1998), "Social Benefits of Reducing Air Pollution in the Buenos Aires Metropolitan Area", Annex 1 in Weaver and Balam (1998), Air Quality Component of the Argentina Pollution Management Project, Volume 2, Engine, Fuel and Emissions Engineering Inc.

Cropper Maureen (2000), "Has Economic Research Answered the Needs of Environmental Policy?", *Journal of Environmental Economics and Management*, Volume 39, Number 3, p.328-350.

FB (1999), "Consumo de gas natural y emisiones de gases por el sistema de transporte carretero y generación eléctrica en Argentina (1997-2015)", IDEE/FB.

FC (1999), "Aire y ruido en Buenos Aires", Programa Foros Participativos para una Ciudad Sustentable, Fundación Ciudad.

Jones-Lee, M. et al. (1985), "The Value of Safety: the Results of a National Sample Survey", *Economic Journal*, Vol.95, No.377, pp.49-72.

LA NACIÓN, 1994-1995. Periódico matutino; Buenos Aires, Argentina.

Loomis, D., Castillejos, M., Gold, D.R., Donnell, W.M., and Borja-Aburto, V.H. (1999), "Air Pollution and Infant Mortality in Mexico City", *Epidemiology*, 10, 118-123.

Maddison, D., Lvovsky, K., Hughes, G., and Pearce, D. (1997), "Air Pollution and the Social Costs of Fuels: A Methodology with Application to Eight Cities", World Bank Environment Department Paper.

MEOySP (1994), "Educación y Salud: Resultados de Mediciones sobre Acceso y Cobertura", Secretaría de Programación Económica, Proyecto ARG/93/029.

MSPBA (1996), "Boletín de Estadísticas Vitales y Demográficas", Ministerio de Salud de la Provincia de Buenos Aires, No.2.

MSPBA (1993), "Rendimientos Hospitalarios: Subsector Oficial", Ministerio de Salud, provincia de Buenos Aires, Anuario 1993.

MSyAS (1993), “Egresos de Establecimientos Oficiales por Diagnósticos. Total país. Jurisdicciones”, Ministerio de Salud y Acción Social de la Nación, Serie 4, No.16 y No.17.

MSyAS (1994), “Exploraciones sobre las bases sociales del gasto en salud”, *Programa Nacional de Asistencia Técnica para la Administración de los Servicios Sociales en la Argentina (Gob.Arg./BIRF/PNUD).*

MSyAS (1996a.), “Agrupamiento de causas de mortalidad por jurisdicción de residencia, edad y sexo”, Ministerio de Salud y Acción Social de la Nación, Serie 1, No.73.

MSyAS (1996b.), “Estadísticas vitales de recursos y producción de servicios de salud”, Ministerio de Salud y Acción Social de la Nación, Serie 1, No.74.

MSyAS (1996c.), “Módulo de utilización y gasto en servicios de salud: aglomerado Gran Buenos Aires 1995”, Ministerio de Salud y Acción Social de la Nación, Serie 10, No.12.

MTSS (1997), “Boletín de Estadísticas Laborales”, 1er. Semestre 1996.

OMS (1974), Red panamericana de muestreo de la contaminación del aire. División Salud Ambiental. Serie técnica 18. OPS.

Ostro B., Sánchez, J.M. Aranda, C., and Eskeland, G. (1996), “Air Pollution and Mortality: Results from a Study in Santiago Chile”, *Journal of Exposure Analysis and Environmental Epidemiology*, 6:97-114.

Ostro, B.D. (1987): “Air Pollution and Morbidity Revisited: A Specification Test”; *Journal of Environmental Economics and Management*, 14:87-98.

Seroa da Motta, R. and Mendes, A.P. (1996), “Health Costs Associated with Air Pollution in Brazil”, chapter 5 in P. May and R. Seroa da Motta (orgs.) *Price the Earth*, New York, Columbia Press.

US-EPA (1996) “Regulatory Impact Analysis for Proposed Particulate Matter National Ambient Air Quality Standard”, Office of Air Quality Planning and Standards, December.

US-EPA (1996), “Regulatory Impact Analysis for Proposed Ozone National Ambient Air Quality Standard”, Office of Air Quality Planning and Standards, December.

V. de Flood (1996), “El Mercado de Salud en Argentina: Las Obras Sociales”, Instituto Superior de Economistas de Gobierno, Universidad de San Andrés.

WB (1994a.), “Thailand: Mitigating Pollution and Congestion Impacts in a High-growth Economy: Country Economic Report”, Country Operations Division, Country Department I. East Asia and Pacific Region, Report No. 11770-TH, February.

WB (1994b.), “Estimating the Health Effects of Air Pollutants: A Method with an Application to Jakarta”, World Bank Policy Research Department, Public Economics Division, Policy Research Working Paper No.1301, May.

WB (1994c.), “Chile: Managing Environmental Problems: Economic Analysis of Selected Issues”, Environmental and Urban Development Division, Country Department I, Latin America and the Caribbean Region, Report No. 13061-CH, December.

WB (1998), Clean Air Initiative in Latin American Cities, City Action Plans (http://www.worldbank.org/wbi/cleanair/).

Weaver, C. and Balam, M. (1998), Air Quality Component of the Argentina Pollution Management Project, Volume 2, Engine, Fuel and Emissions Engineering Inc.

WHO-UNEP (1992), EARTHWATCH (Global Environmental Monitoring System): Urban Air Pollution in Megacities of the World. Blackwell Publishers, U.K.